CONIDIUM PRODUCTION IN PENICILLIUM[1]

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Certain morphological features are common to the species which for convenience are lumped together under the generic name, *Penicillium.*

CONIDIOPHORES

The fertile hyphae or conidiophores may arise as branches from submerged or from aerial hyphae. They are septate except when they are very short. They have approximately the same diameter as the vegetative hyphae from which they branch. They are uniform in diameter from point of origin to the point where the conidium-producing complex of cells begins to form. The apex of the uppermost cell is frequently though not always swollen somewhat like the vesicle of *Aspergillus,* and the distal ends of branches if such are present are commonly also swollen, but the appearance of such swelling is not a uniform character within the species. The conidiophore proper should be measured from the point of origin to the base of the fruiting group of cells or branches. This part ceases to grow in length when fruiting commences, hence this measurement is more characteristic than a measurement including fruiting mass which frequently increases in length for several weeks by the production of new conidia.

CONIDIAL APPARATUS[2]

The essential organ of conidium production in this group is the fertile cell which has been differently named by various workers as a basidium by Brefeld, Stoll, the writer in part, as sterigma, by Westling, Bainier, Wehmer, and others. The term "conidiiferous cell" was used in the English descriptions of writer's previous paper because the word had no morphological significance in

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[2] This section of the paper was presented to the Botanical Society of America at Washington, D. C., December 27, 1911, under the title "The Connective between Conidia of *Penicillium,*" with an abstract appearing in Science, N. S., vol. 35, no. 891, January 26, 1912, pp. 149–150.

other groups. The use of these terms has been fully discussed by Westling[3] who prefers the term sterigma. These fertile cells are uninucleate, tubular rather than flaskshaped. While not uniform in diameter such swelling as is found is usually about the middle of the length. The variations in shape are such as may be easily attributed to the effect of crowding many such cells into compact verticils upon the dome-like apex of the fertile branch. The diameter of the cell is usually a little less than that of the branch below it. The tubular form with an average diameter is maintained to a length varying somewhat but fairly characteristic for each species. There is, then, a more or less abrupt reduction to a smaller tube (figure a), from which the conidia arise. This tube may be found to vary within the field of the microscope from imperceptible to several microns in length.

CONIDIUM FORMATION

The process of conidium formation as far as it has been followed cytologically, involves the division of the cell nucleus, the migration of one of the daughter nuclei to the tip of the tube which grows rapidly in length, the formation of a cross-wall in the tube at a distance from the tip characteristic for the species, and the swelling of the new conidium to the size and shape typical for the species. Some preparations give no hint of this process. If conidium formation be for some reason arrested, the newest conidium may rest directly upon the basal cell without a vestige of a tube between. In other cases, a tube several microns long may separate the conidium from the main body of the parent cell. Every gradation may be found in the same culture if it is watched over a period of several days to several weeks. No species has shown conidia globose from the first. Such appearances may be easily found but examination of fresher or younger colonies shows them to be misleading. However quickly the stage may pass, the conidium of Penicillium arises as a cylindrical or barrel-shaped segment cut by cross-wall from the end of the fertile tube of the conidiiferous cell. This tube was designated by the writer in a previous paper as the sterigma because of its really permanent character as a conidium-forming organ of the cell. One might reasonably designate it a character of the genus.

[3] Westling, R., Arkiv. f. Bot. Bd. II (1911), no. 1, pp. 1–156.

CONNECTIVE

Once formed, the conidium reaches characteristic form and size by swelling and laying down new walls for itself within the primary wall which is continuous with that of the parent cell. The appearance of a connective (bridge, or disjunctor) is due to this old wall. The presence of this connective is figured by various authors and noted as common, but without explanation by Westling. The appearance arises in certain species[4] and especially in particular media from the swelling and rounding up of the new cell within the old wall. Such formation is more frequent in

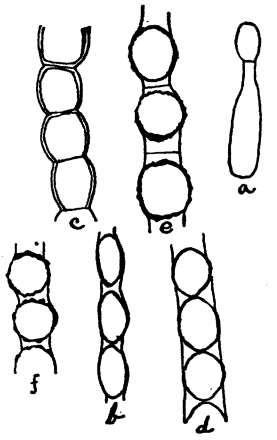

FIG. 1. Conidium formation and the connective in *Penicillium*: *a*, conidium-bearing cell showing the tube and a conidium in its elliptical stage; *b, d, f,* chains of conidia showing different appearances of the connective but no cross-walls; *c, e,* chains of conidia in which the original cross-wall shows.

media poor in nutrients especially in carbohydrates. In such cases the new wall following the plasma membrane, splits away from the old at the ends of the cell leaving an apparently empty space bridged across by the lines made by the primary wall. In especially favorable cases the original cross wall can be traced. Commonly the cells remain in contact with the center of the cross-wall where doubtless protoplasmic connections from cell to cell are continued for some time. In many cases, interpretation of the appearance would be impossible unless the true arrangement of walls had been traced out in these favorable forms.

[4] These statements are equally true for all species of Aspergillus examined by the writer.

In preparations which show no connective the explanation is equally simple, the primary wall adheres to the new or secondary wall, and takes the shape of the new cell. In some species conidia are delicately granular, rough, or spinulose in particular rows or cultures and not in others. There is some reason to think that these cases of conidia occasionally granular are due to the presence of this old wall which takes that form under such conditions and not under others. It has not been possible to define these conditions or prove the suggestion thus far.

SHAPE AND MEASUREMENTS OF CONIDIA

Much weight has been frequently given to shape and measurement of conidia. Westling has based his key to species upon data of this kind. Examination of his descriptions shows that he has seen the great variation of both factors even in cultures upon prune-gelatine. When successive cultures upon media of decidedly different composition are compared the contrasts become greater still. Even upon a single medium the difficulty of determining which of the sizes and shapes shall be taken as typical is noted by Westling himself, and fully appreciated by the writer with Westling's own cultures and his paper in hand for verification upon prune-gelatine. As noted by Westling in his descriptions of species certain forms give very uniform data while others are variable. Among these variable forms, the conidia may be nearly all definitely elliptical in one culture and predominantly globose upon the next culture in another substratum but grown from these elliptical spores.

METULAE

Westling has measured and described carefully the branches bearing the conidiiferous cells or sterigmata. To these he gives the new name metulae. In certain species the new term is found significant and useful. In others, attempts to place value upon the study of these branches as metulae have proved difficult. A considerable number of the forms studied show present in this position branches of very unequal length. Occasionally the same verticil would contain sterigmata, metulae and a main central branch bearing another verticil of metulae above; the metulae would thus be

formed in primary, secondary or tertiary branching groups or verticils in the same fruit mass. In other species it would be necessary to record metulae as absent so that the conidia-bearing verticils would be produced directly upon the apices of the conidiophore and its branches. This latter conception can be readily applied in a few species. Descriptions and figuring of branching systems as typical for species involves many difficulties as is recently noted by Wehmer.[5] In the same culture, corresponding septa of different conidial masses may show, single, opposite, or verticillate branching, with a change of nutrient the variation may be carried in one direction or another. Literal following of the keys furnished for generic discrimination might place different fruits of the same colony in several genera.

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[5] Wehmer, C. Mycologisches Centralblatt, Bd. II (1913), heft 4, p. 197.